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EXPANDING FOOD CROP RESEARCH IN THE DRY TROPICAL REGION OF WEST AFRICA

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EXPANDING FOOD CROP RESEARCH

IN THE DRY TROPICAL REGION OF WEST AFRICA

- C O N T E N T S -

ANNEXES

The tropical regions include the great majority of the developing countries. By 1985 (according to FAO studies), the effect of population increases and a certain rise in the standard of living in these countries will be to double or in some cases even triple the food requirements, which at present are not always properly met.

The problem is likely to become particularly difficult to solve in the dry tropical of West Africa where the food crops adapted to these regions such as millet, sorghum and some legumes (the most important being coupes : Vigna unguiculata) at present only reach a poor standard of production;

At the world level, the authorities responsible for food crop development research have concentrated on the cereal crops in the dry regions of Asia where millet and sorghum are also found.

The International Agricultural Research Advisory Group, with its secretariat at the World Bank, and the Technical Advisory Committee have approved the recommendations of the 3 experts, Messrs CUMMINGS, DOGGET and SAUGER, who in August 1971 undertook to assess the problems involved in developing research in the dry tropical regions of Africa and Asia.

The report submitted by these experts proposed :

- creating on International Crop Research Institute for the semi-arid tropics, to be set up in India (ICRISAT),
- and, without waiting for this Institute to be set up or the work started, expanding the national or regional research programmes dealing with these same crops particularly in West Africa where the food problem is acute and the regionally organized research work already well advanced.

The aim of this report is to define a programme for strengthening the existing facilities and to specify the modalities for applying it, and in particular, liaison with the work undertaken by ICRISAT.

I - MAIN FEATURES OF THE DRY TROPICAL ZONE OF WEST AFRICA (ECOLOGIE-CROPS)

The climate of the region in question comes under the semi-arid climate, which may be roughly defined as having a rainy season of 3 $\frac{1}{2}$ to 7 months and a dry season of 5 to 7 $\frac{1}{2}$ months. In this zone the climate is uniform to a certain extent and the types of soil rather similar (including the tropical ferruginous group).

In particular, it covers the territories of the following States :

Senegal, Mali, Upper Volta, Niger, Northern Nigeria, Northern Ghana and larger or smaller parts of the territories of a number of other states mentioned below in the list of millet (Pennisetum)* and sorghum producing countries.

These two cereals, which originated in Africa, give the some a degree of uniformity from the agro-ecological standpoint, and this is emphasized by the leguminous crop : cowpea, which is grown extensively.

In fact this species (Vigna unguiculata), which originated in Tropical Africa, is not only grown in the dry tropical zones involved, but also in the wetter zones, which explains why it is included in the IITA programme. This should not however conceal the fact that the growing area extende mainly over the dry zone where cowpea happens to be particularly important because of its resistance to drought and since in fact hardly any other species are known with such valuable agronomical and nutritional characteristics for this zone.

There are a great number of varieties and their adaptation to the harsh conditions described above shows that the problems must be treated separately from those encountered in the humid tropics.

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* - In the rest of the text the term "millet" will simply be used and will always refer to the species Pennisetum typhoïdes.

II - ECONOMICS OF THE MAIN FOOD CROPS

The main food crops in this zone are : sorghum, millet and cowpea.

The following table, which is based on information taken from the FAO Year Book for 1969, gives an idea of the outputs and yields of millet and sorghum over a wast area of Tropical Africa covering far more than the dry tropical zone of West Africa alone.

	Sorghum + Millet		
	Areas (ha)	Outputs (t)	Yields (kg/ha)
Cameroun (North)	500 000	350 000	700
Central African Republic	65 000	45 000	690
Chad	1 047 000	711 000	680
Dahomey (North)	100 000	50 000	500
Ghana (North)	291 000	156 000	530
Guinea (North)	260 000	150 000	500
Ivory Coast (North)	112 000	64 000	570
Mali	910 000	757 000	830
Niger	2 300 000	1 060 000	460
Nigeria (North)*	10 200 000	6 300 000	610
Senegal (North)	1 036 000	454 000	440
Togo (North)	312 000	140 000	450
Upper Volta	1 975 000	1 726 000	870

* - The seven Northern States represent, for sorghum, 5 017 000 ha with an output of 2 820 000 metric tons and a yield of 563 kg/ha. For millet (6 States) : 4 477 680 ha with an output of 2 190 500 metric tons and a yield of 490 kg/ha.

The relative importance of millet and sorghum varies with the latitude, the degree of exhaustion of the soils and the particular preferences of each population.

The sorghum is predominant in the Central African Republic (100 %), Cameroun (86 %), Chad (74 %), Togo (71 %), Upper Volta (62 %) and Nigeria (56 %).

In Mali and Ivory Coast, millet and sorghum are approximately equal, whereas in Niger and Senegal millet is grown more than sorghum.

Generally speaking, yields are low; for the West African countries, on average they do not exceed one metric ton, and more frequently they are between 550 and 700 kg/ha.

As for cowpea (Vigna unguiculata) it is only possible to give output estimates that are not so accurate but which

nevertheless provide a good indication. Very little information is available on the areas under this legume crop and the figures are so vague that they are not mentioned here. This is mainly due to the fact that cowpea is very often intercropped or grown as a catch crop with these cereals.

	Cowpea
	Output in metric tons
Dahomey	20 000
Mauritania	5 000
Niger	75 000
Nigeria	700 000
Senegal	20 000
Togo	25 000
Upper Volta	95 000

The yields in Niger are approximately 100 to 150 kg/ha

* *
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Food crop yields are seen to be generally low, which often means that outputs are not sufficient to meet national requirements, and the situation is in fact made even worse by other unfavourable factors.

Among these unfavourable factors, mention should be made of :

. losses due to crop enemies (insects, disease, weeds).

For Africa, the FAO World Plan assesses these losses (for the whole of plant production) as follows for 1970 :

Losses due to insects : 13.0 %
Losses due to disease : 12.9 %
Losses due to weeds : 15.7 %

41.6 %

This situation is found in the semi arid region of African whose characteristic features are finally :

a) - a latent of intermittent food shortage : production, which is for consumption by the population that grows the crops, is sufficient in good years but insufficient in bad years,

- rising imports of food produce, rice, wheat, vegetables, etc.

This is partly due to the lack of production organization, insufficient knowledge on requirements and outlets, and also the fact that the consumers are to a certain degree turning away from products which involve very demanding post-harvest processing (threshing, milling, cooking, etc.). From this point of view, pearl millet provides a very revealing example. This cereal is in fact still the staple and preferred element in the diet of the populations in the zone. It will remain so for a long time, in spite of a justifiable desire to diversify nutrition, providing, however, new rapid techniques are formulated to make it as simple to prepare as rice and wheat.

b)- The present low standard of productivity of the farms which are small and characteristically use hardy plants and manual labour, and will remain almost completely self-sufficient until a cash crop is introduced. This standard can only be raised, as it must be, by intensive research efforts on undertaking fundamental research and combining it on the rural farms.

III - PRESENT RESEARCH ON FOOD CROPS IN FRENCH AND IN ENGLISH-SPEAKING AFRICA

A) Existing scientific facilities in West Africa

All the food crop problems of the dry tropical zone have formed research subjects that have been dealt with for more than a decade in the tropical region of West Africa.

This research work has mainly been undertaken within the framework of two structures :

- in the French-speaking countries, by IRAT, based at the Bambey Centre (Senegal),
- in the English-speaking countries from the Institute of Agricultural Research, Samaru (Northern Nigeria), which belongs, to the Ahmadu Bello University.

1. Institut des Recherches Agronomiques Tropicales (IRAT)

This body, which works within the Franco-African Co-operation framework, carries out its research programmes for the semi-arid zones on a regional basis consisting of :

A regional centre, a subsidiary centre and a network of stations in four States in French-speaking West Africa :

Senegal, Mali, Upper Volta, Niger.

The stations are sited to take into account a division, along the 800 mm isohyet, into two ecological zones, mainly with regard to variety improvement constraints.

- Early variety zone (rainfall of less than 800 mm)
  - . Main Centre : Bambey Centre (Senegal)
  - . Network stations : Tarna (Niger),
    Richard-Toll (North Senegal)
    Kogoni (Mali)
    Kolo (Niger)
- Late variety zone (rainfall of more than 800 mm)
  - . Subsidiary centre : Upper Volta (at present Saria, but it may be set up at Farako-Ba, a station near Bobo-Dioulasso, which would be very desirable).
  - . Stations : Farako-Ba (Upper Volta),
    Ina (North Dahomey)
    Sotuba (Mali)

    Sefa (Senegal, Sikasso (Mali)

The staff is divided between the Bambey Centre (Senegal), which takes the largest share, and the stations both in Senegal and the other States in the region (Mali, Upper Volta, Niger).

To carry out its research on millet, sorghum and cowpea, the Bambey Regional Centre has :

2 plant breeders
1 agropedologist
1 plant pathologist
1 agronomist

In addition, the following specialists devote most of their work to these crops or related problems :

1 entomologist
1 bioclimatologist
1 physiologist
1 specialist in agricultural machinery
1 agricultural economist
1 specialist in farming systems
1 expert in pre-extension work

A full-scale study of the practical application of research results is made in the actual environment within a special experimental framework in which research workers and development officers work in association : Experimental Development Units.

In liaison with the Bambey Centre, the existing research network for millet, sorghum and food legumes in the countries of the Region includes :

1 plant breeder and 1 agro-pedologist in Upper Volta
1 plant breeder and 1 agronomist in Niger

The financial costs of the corresponding programmes represent an annual expenditure of $ 900 000, half of which is provided by France and half by the African States concerned.

2. The European Development Fund finances a special research project on millet at Bambey, which is managed by IRAT and employs 2 geneticists (provided by ORSTOM) and a physiologist (IRAT).

3. The Institute of Agricultural Research of Ahmadu Bello University (IAR) at Samaru (Northern Nigeria) with the Joint Project 26 (OUA/STRC) group of research workers, consisting of :

1 geneticist millet-sorghum (20 %) - maize (80 %)

1 entomologist millet and sorghum

1 plant pathologist millet-sorghum (80 %) - maize (20 %)

1 soil specialist millet-sorghum (40 %) - maize (60 %)

To this team must be added the IAR research workers (cf. Annex IV), or 3 full-time and 17 part-time research workers, representing 8 research worker units. The total with Joint Project 26 represents 12 research worker units.

The programme is centred mainly upon obtaining high-yielding varieties. Joint trials are organized by this project on a network consisting of all the West African stations concerned by this programme, and particularly the IRAT network of stations.

In this way, IRAT, the Ahmadu Bello Agricultural Research Institute and Joint Project n° 26 represent a substantial body of closely combined research, forming a high quality scientific structure. Dividing the research between the two main Centres at Bambey and Samaru with their regional stations has not at all prejudiced the effectiveness of the research, quite the contrary.

B) Results obtained

The annex to this report gives a summary of the results obtained in this zone both by IRAT and IAR, Samaru.

These research results on millet, sorghum and cowpea, involve :

- creating highly-productive plants,
- crop protection,
- studying and transforming the natural environment,
- intensifying the crop systems,
- post-harvest technology,
- stored produce protection.

These subjects are dealt with in the expansion programme described below.

Very substantial results have already been obtained from the Bambey Centre with the network of stations connected with it. The regional basis on which they are obtained makes them applicable to the whole of the ecological region of which Bambey is quite typical. They have already led to considerable applications in the rural environment.

The existing liaison between this network in the French-speaking States and the research work undertaken on the same subjects in the English-speaking countries (Nigeria), makes it possible to extend these results easily.

C) The need for more intensive research

Bearing in mind the considerable importance of sorghum millet, maize and cowpea as human foodstuffs and for the economies of the countries in the semi-arid zone, a more intensive effort must be made to give the farmers in these countries a chance to free themselves of their poverty. To obtain high-yielding varieties rapidly and specify their growing conditions, the research programmes in progress must be expanded to solve the problems that it has not been possible to deal with.

This leap forward is only possible if additional resources can be utilized to expand the programme undertaken both in the French-speaking countries (Bambey) and in the English-speaking countries (Samaru).

Apart from the EDF contribution, the funds for supporting the teams of research workers at present operating in the French-speaking countries represent for France and the countries involved an annual total of 5,000,000 FF or slightly more than $ 1,000,000, of which half is provided by France and half by Senegal, Upper Volta and Niger.

The EDF programme at Bambey represents an annuel total of 975,000 FF or $ 195,000.

The cost of Joint Project 26 is 300,000 $ per annum. IAR costs represent $ 102,500 or about $ 310,000.

The total expenditure for research on sorghum-millet, maize and cowpea in West Africa at present therefore amonts to $ 1,800,000 per annum.

A further substantial financial effort cannot be expected from Nigeria any more than from the French-speaking States or France who at present finance most of the programmes in progress. Aid must be sought from a new outside source, as planned by the work of the International Agricultural Research Advisory Group which confirmed the conclusions of the CUMMINGS-DOGGETT-SAUGER Report.

It is moreover obvious that the food crop research programme should be expanded in liaison with the work undertaken by ICRISAT. This work will be useful for Africa and, conversely, the results already obtained in Africa will be valuable for ICRISAT.

It is in this context that the expanded cereal and cowpea research programme for this semi-arid zone of West Africa has been planned. The conditions for implementing this programme will be specified in the last part of this paper.

IV - EXPANDED PROGRAMME

1 - CREATING HIGH-YIELDING PLANTS

The following programme has been formulated by taking into consideration the requirements due to the desire to increase cereal and food legume outputs together with the farmers'overall income and bearing in mind the work in progress which is integrated in the new programme. The expansion programme presupposes close liaison with the work indertaken by ICRISAT.

/ a. Cereal Improvement/

The programme obviously includes continuing the work at present being undertaken. The main objectives of this work are briefly recalle here :

- reducing the length of the straw on the local varieties : obtaining straw/grain ratios of about 2, the only ones likely to make advanced cultural techniques more profitable;
- shortening the cycle, which is warranted for physiological, agronomic and plant protection reasons;
- obtaining grains with the desired technological, organoleptic and nutritional characteristics;
- research to obtain good nutritive qualities, and in particular higher protein contents, a proper balance of amino-acids and the presence of the more valuable amino-acids such as lysine or methionine;
- research into disease-ressitant varieties; very special attention must be paid to this aspect of the work, since variety resistance forms the best crop protection method and is to be preferred to all others which will, of necessity, be more costly.

For the two main cereals, it is worth defininf the lines of research within the general plan.

- Pearl millet -

The dwarf millets of the cereal type form the subject of the EDF Project (ORSTOM-IRAT) carried out under an agreement with the Senegal Governement. From the existing plants it is planned to create a new type of plant with characteristics specified by physiological research (length of internodes, leaf habit, etc.); this new type will have to be adapted to agronomical needs and, in particular, meet yield requirements.

At the end of the selection work it is hoped to obtain types yielding 7 t/ha by using the synthetic varieties, and perhaps even simple hybrids created with sterile male lines.

Exploiting the plants created in this way, which is partly planned in the Project, may be carried out more intensively by working on a regional basis for the different areas in the zone.

Furthermore, it has been shown that in the Savanna countries and under farming systems where irrigation cannot be applied, only annual fodder crops could provide a sufficient amount of dry matter and, notably, pearl millet.

Feeding draught animals and fat stock is a major concern for this region and a selection programme for millets of the fodder type which can be grown on a large scale with mechanized farming, may prove to be very advisable.

This work should be undertaken immediately, since the fodder aspect has not been included in the selection criteria of this project and very valuable types could be irretrievably lost.

It is worth remembering the importance that the selection work should attach to characters of resistance to "mildew" (Sclerospora graminicola) particularly for the dwarf varieties. Smut (Tolyposporium penicillariae) must also be taken into consideration, as well as possible resistance to sugary disease (Sphacelia sorghi) and borers. Striga is a serious problem on millet in the Sudan zone and has not yet been studied as is required.

- Sorghum -

Work on creating dwarf varieties with good grain qualities (horny texture, no brown layer, grain that is ivory or with a yellow endosperm, resistance to mould and fusarium) which are early (100 days from sowing to harvest) to semi-early (120 days) should be speeded up. Good genetic foundations exist already. They should be increased and, bearing in mind the high potentials of this cereal, greater resources should be utilized in carrying out selection work with, in particular, the physiolmgist, plant pathologist and entomologist operating in conjunction with the plant breeder.

The suitability of a second growth of sorghum may also be studied, together with the drought-resistance character within the framework of joint studies by the geneticist, physiologist and bioclimatologist.

Serious damage is caused by a root disease in Nigeria. The cause is unknown and the disease needs to be studied.

For this species, just as for millet, selection work must provide an economic solution to the problem of parasite resistance. In the case of sorghum, the most important problem

seems to be that of the sorghum shoot fly (Atherigona sp.); resistance to the Cecidomyia (Contarinia sorghicola) is still a permanent objective. Striga is causing great concern in Nigeria and throughout the wetter part of the zone involved.

Selection work in the IRAT stations is at present well under way through the process of crosses and extracting lines from the descendants, and by using heterogenesis and creating adapted sterile male lines (height, rate of maturity, grain qualities) which are already well advanced.

/ b. Improvement of legumes /

- Cowpea -

A number of improved varieties are already available. Further progress however needs to be made in research into short-cycle plants with grouped inflorescences whose grain characteristics meet consumer requirements.

It is essential to fromulate very high-yielding varieties, all the more so as crop protection treatments still appear to be necessary.

Studies must be carried out on the type of growth, morphology and flowering and fruiting phenomena on Vigna. Substantial progress in variety improvement depends on these studies.

- Soya -

This legume has been the subject of work in the temperate and sub-tropical zones.

It appears to be of great value for development in the semi-arid zones : efforts must therefore be made to create varieties adapted to the tropical regions with acceptable yields for local consumption.

This work has already been started in the humid tropics it should be extended to the dry tropical zone.

2 - BASIC SEED PRODCUTION - SEED ANALYSIS

This part of the programme needs to be expanded. It is moreover in full expansion, but it is already the subject of a European D velopment Fund special project : so there is no need to plan greater resources. It should however be noted that this programme is inadequate from some points of view, and particularly with regard to the training of officers to take charge of producing hybrids.

3 - CROP PROTECTION

For all aspects connected with understanding the processes of variety resistance, the emphasis must be placed upon plant pathology ; in entomology, special attention should be paid to the problems of the vitality of pest populations, the reasons for the variations and, in this way, to research into agricultural and biological control methods which are generally preferable to chemical control, which is too expansive. The main problems to be studied are as follows :

- Millet -

Mildew - Research into the conditions for genetic determination of variety resistance and, more particularly, studying the way in which the fungus penetrates the plant and formulating an inoculation technique for Sclerospora graminicola.

Smut (Tolyposporium penicillariae) should also be studied from the variety resistance standpoint rather than through fungicide treatments, as should Sphacelia sorghi.

Millet 'borers", particularly Acigona ignefusalis, are likely to become more serious when the dwarf varieties being studied have been obtained. More resistant varieties should be chosen, and the methods of resistance need to be determined and biological control developed.

- Sorghum -

Mould on the grain forms the most important plant pathology due to the susceptibility of many new varieties and the fact that selection work is aimed at an early harvest before the end of the rains. Solutions need to be found.

The sorhum shoot fly (Atherigona sp.) is a very serious problem in India and must be taken into account when the highly profitable varieties are studied, since some are particularly susceptible to attacks. The criteria for this susceptibility studied form a general standpoint, will have to be carried over to the conditions in Africa, and the cycle and vitality of the insect determined according to the climates and growing methods. Thus, in Senegal and Nigeria, serious attacks only occur on late sowings.

For the cecidomyia of the panicle, Contarinia sorghicola, which has already been studied, it is worth examining the conditions under which it multiplies in terms of the cropping systems. Studyint its vitality should make it possible to specify the varieties and cultural calendars to be recommended for each region. Here again, variety resistance is and element that should be studied in detail.

Lastly, sorghum borers may be dealt with by research into biological control solutions. The sorghum borer is a serious problem in Nigeria, in the wetter areas, the main borer being Bossolea fusca.

- Cowpea -

Further studies on the entomological fauna should lead to better knowledge of the reasons why some species appear and may make it possible to prevent them. Nevertheless, chemical control will still be the most appropriate soultion for a long time. It will be advisable, while following the progress of variety selection, to find the most economical treatments for the varieties that meet the requirements of chemical control (short cycle, grouped inflorescence, erect habit).

4 - STUDY AND TRANSFORMATION OF THE NATURAL ENVIRONMENT

/a. Soils/

The work mentioned above must of course be continued and developed along the following lines :

- regional crop suitability : studying the land, developing and standardizing the agroclimatological observation network : frequency analysis of rainfall ;

- physical factors of fertility :

  . the part played by organic matter in the soil structure;
  . the influence of the physical state of the soil on the dynamics of water in the profile and on the water nutrition of the crops

- soil fertility maintenance :

  . studying the causes of the deterioration of the soil (elements removed by the crops, oblique and vertical drainage, fixation and insolubilization of phosphorus)
  . experiments with new forms of fertilizer with high proportions of fertilizing elements.

Special attention must be paid to the following points

- the effects of the different tillage methods which, particularly in Nigeria, have not yet been adequately studied,

- the balance, and in particular the mineral balance, of the semi-intensive systems proposed and being tested, and especially rapid diagnosis of any possible phenomena caused by this innovation : deficiencies, toxicity, lack of balance (using lysimeters in the field, in particular). Special mention must be made of the harmful appearances of sorghum on the following plants in the rotation. This problem

should be studied thoroughly, since sorghum represents a great possibility for a large part of the zone in question,

- more thorough knowledge of the dynamics of the mineral elements in the soil leading particularly to the notion of the possible supply output on the soil of nutrient elements for the cultivated plant,

- bringing this 'soil output' to the same level as the plant's immediate requirements during its different stages of growth and development and its absorption capacity, especially with the new plant morphological structures described above,

- physiological diagnosis of the differences between the possible supply output and the requirements or absorption capacity; using new methods, such as 'sap diagnosis', seem to be particularly desirable for this,

- the biochemical properties of the soils and especially the part played by ploughed-in organic matter on the balance of microbe populations in the soil and the nitrogen nutrition of the cereals. Study of the denitrification phenomena will be included in the programme.

Studying the effect of the rhizosphere in adjusting this soil output to the plant's immediate requirements seems to be particularly worthwhile in the case of grain legumes on which root nodules usually form easily.

This is, as it happens, the case for cowpea, soya and groundnuts, plants for which the process of nitrogen fixation by rhizobium and the restitution of this fixed nitrogen under the special conditions in the dry tropical zone need to be studied more thoroughly, or even determined in some cases.

Attention should be paid to the economic importance of nitrogen fixation, by the root nodules of legume crops, on the overall fertilizer balance of the rotation.

/ b. Climate factors /

Present knowledge is inadequate to be able to determine accurately the adjustment of the plant's requirements to the supplies in the soil.

To study these questions it is proposed to form teams consisting of a bioclimatologist and a hydraulics expert in two or three sites and especially where they can be helped by the

existing specialists in soil science, soil physics, physiology, plant breeding, agricultural machinery and economics, without whom these two-man teams would not be able to explain or control the phenomena they produce.

These teams should work both on dry crops, by studying the advisability of providing supplementary irrigation or limiting the requirements (wind-breaks), and at the micro-hydraulic level (small drainage basins and valleys) as well as on large-scale hydro-agricultural developments.

Their programme would include studying the following subjects :

- water requirements of the crops according to their development and the climate,
- research into varieties with the best water use coefficient
- irrigation rates according to the types of soil,
- the most suitable methods of applying water,
- tillage methods and developments producing the best water balance,
- economic studies on the gross increases in production and the net incomes according to the development systems and amounts of water applied.

5 - INTENSIFICATION OF THE CROPPING SYSTEMS

As has been shown, the work on intensifying the cropping systems requires the collaboration of various specialists : agronomists, specialists in agricultural machinery and agricultural economics.

The Experimental Development Units have proved to form a suitable research structure, now that the "running-in" and adaptation period has come to an end.

The work already undertaken must be continued, and special emphasis will be placed on economic studies that have a particularly important part to play in this research work.

6 - POST-HARVEST TECHNOLOGY

Programme

- threashing in the field or on the farm, the technical aspects (perfecting the machines) and psycho-economic advantages of mechanizing this operation. A millet threshing machine has been perfected at Bambey. It is suitable for use at the village level.

- storing, on the farm and at the co-operative. These studies may lead to dealing with drying methods which may prove essential in the wetter zones (in ears, panicles or grain). They should be undertaken with the specialist in stored produce produce protectio, since at this level the damage caused by insects and fungi may be serious (for millet and sorghum as well as for cowpea).

  At this stage a study should also be made of the effect of pesticide treatments applied in the field or during prestorage.

- processing the grain (shelling and milling) on the farm or at the co-operative, in conjunction with the Food Technology Institute, Dakar, and SOTRANIL, Zinder (FAO Project) which deal with the matter on an industrial level.

- economic assessment of production costs on the farm for comparison with the possible market prices, according to the possible foreign and home markets.

This study is particularly important for the cereals, if it is assumed that they are to be transformed into meat :

- setting a ceiling price for production, and compatibility with the economics of the more intensive systems proposed.

- selling the unprocessed cereals on the farm or making the maximum use of them by fattening stock on the same farm.

7 - STORED PRODUCE PROTECTION

The protection of harvested seed forms by itself a considerable and essential field of research for cowpea.

Exhaustive studies for assessing losses must be undertaken while at the same time the following work must be continued :

- research, in the stations, on storage installations and techniques
- experiments, in the rural environment, backed up by the network of sub-stations and trial sites, on applying these techniques,
- special emphasis will be placed on harvesting and pre-storage techniques likely to improve the conditions for storage proper.

8 - TRAINING

By their very example and the nature of the work they undertake, the research workers can encourage the young Africans working with them to take this work. Since few people in Africa are going in for research, it is important to promote this career by providing scientific training. The research centres where the programmes are carried out have an essential part to play in the pre-service and in-service training of African research workers and technicians.

Moreover, a real effort is already being made along these lines :

The Samaru Centre, which is directly connected with the University, is very much involved with training, since most of the IAR research workers teach at the University regularly and receive trainees who are preparing various types of theses up to the highest level.

Although it does not have the same facilities as Samaru, the Bambey Research Centre acts, in fact, as a practical scientific training centre for young African graduates who are interested in agricultural research.

After their years at University or higher education institutes where they have been awarded a diploma or a degree in science, these young people generally follow a one or two year specialized scientific training is completed by a full year at Bambey, to obtain "on the spot" experience of research work.

But at the present time the scope of these efforts is still limited and in practice it is still necessary to send the young research workers to Europe or the United States to finish their training. By increasing the scientific facilities and forming teams of specialists, it would be possible for the new graduates to work under the best conditions and be given complete training on the spot and, in close liaison with the University of Dakar, obtain the corresponding University diplomas.

This training work obviously implies proper equipment and in particular accommodation facilities which in some cases (at Bambey, notably) are not provided. A full-time specialist should be put in charge of this work.

V - IMPLEMENTING THE EXPANDED PROGRAMME

An assumption may reasonably be made : that over the coming years, the French-speaking African States involved, Nigeria, France, the United Kingdom, EDF and US.AID, will, for Joint Project n° 26 under OAU, continue to provide the same resources as at present.

The only problem involved therefore is to find funds for the extra facilities required for expanding the programme and combining the new and the existing facilities.

On this subject, three questions must be considered :

. determining the extra facilities required,
. the cost of the programme,
. structural organization.

1°) The following table shows the number of research workers engaged on the programmes in progress :

	SENEGAL (Bambey)	UPPER VOLTA and NIGER	NIGERIA (Samaru) (Kano - Mokwa)
Plant improvement	2 geneticists 2 plant breeders	2 plant breeders	5 geneticists (including 2 PT)
Physiology	2 (including 1 PT)		1 (PT)
Crop protection	1 plant pathologist 1 entomologist (PT)		2 plant pathologist 2 entomologists (including 2 PT)
Soil study	1 agropedologist	1 agropedologist	
Bioclimatology	1 (PT)		
Agronomy	1	1	7 (PT)
Agropedology	1		2 (PT)
Agricultural economics	1 (PT)		3 (PT)
Farming system, agricultural machinery and pre-extension work	3 specialists (PT)		3 (PT)
Total number of research workers	13	4	12

(PT) = part time.

The following table gives the extra staff requirements needed to carry out the expanded programme as stated in Chapter IV.

SUBJECT	SITE				TOTAL
	SENEGAL (Bambey)	UPPER VOLTA ~~NIGER~~	NIGERIA (1)		
			SAMARU	KANO AND MOKWA	
Plant improvement	1 sorghum plant breeder	1 sorghum plant breeder	1 sorghum plant breeder		3
		1 millet plant breeder		1 millet plant breeder	2
	1 cowpea plant breeder			1 soya, cowpea plant breeder	2
Physiology	1 physiol.		1 physiol.		2
Crop protection		1 entomol.	1 entomol.		2
Weed study	1				1
Climate study	1	1			2
Agronomy				2	2
Agropedology			1		1
Farming system	1 agricult. economist				1
Experiments				1	1
Technology	1				1
Stored produce protection		1 entomol.			1
Training	1				1
	8	5	3	6	22

(1) - New requirements needed by I.A.R. - Those requirements are expressed supposing the appointments of Joint Project 26 renewed. If that project ended (for 30th June 1975) the appointments now supplied by the project must be involved in the following table. So they would be provided for in the budget from 1975.

2°) Cost of the expansion programme (in US $)

A - Estimated expenditure per research-worker unit per annum

(1) Staff :

1 research worker	34,000	
6 local technicians	9,600	
		43,600

(2) Recurrent expenses :

. labour and farming expenses	16,000	
. equipment and products	4,000	
. inland travelling	1,200	
. foreign travel costs	3,400	
. miscellaneous	200	
. administration (10 % staff and expenses)	2,800	
. symposia - conferences (contribution)	600	
		$ 28,200
TOTAL (1) + (2)		$ 71,800

B - Initial expenditure (per research-worker unit)

. laboratory equipment, furniture	26,000	
. accomodation	30,000	
		$ 56,000
In addition, a special investment for an automatic protein-amino-acid analyser	250,000	

C - Estimated programme expenditure for 5 years

The figures given in (A) correspond to 1972 costs. An average annual increase of 8 % should be allowed for the different items, which amounts to the following per research worker per annum :

Year 1	:	$ 71,800
Year 2	:	$ 77,800
Year 3	:	$ 84,000
Year 4	:	$ 90,800
Year 5	:	$ 96,000

As mentioned on page 22, a further 13 research workers are needed.

The expenditure is estimated as follows (in US $)

	Year 1 8 res. workers	Year 2 13 res. workers	Year 3 13 res. workers	Year 4 13 res. workers	Year 5 13 res. workers	TOTALS
Operating costs	1,148,800	1,711,600	1,848,000	1,997,600	2,112,000	8,828,000
Capital expenditure						
. laboratory equipment accomodation	896,000	336,000				1,232,000
. special equip.	250,000					250,000
	2,294,800	2,047,600	1,848,000	1,997,600	2,112,000	10,310,000

General total : 10,310,000 US $

3°) Structure organization project

The following elements form the main features of the present food crop research structure in West Africa :

- the resources used, which are mainly devoted to two properly equipped centres (Bambey and Samaru) with a subsidiary centre in Upper Volta, are already very effective and, through the close relations between the centres and stations, very substantial results have already been obtained ;

- this structure is financed by different sources, and utilized mainly by IRAT and IAR (Ahmadu Bello) ;

- the effectiveness of the work is in no way impeded by the financing procedure or the relations between these Institutes and the African countries ; quite on the contrary, the fundamental research has been carried out as smoothly as could be desired.

The present research potential can only be increased, as it must be, in order to implement an expanded programme in close liaison with ICRISAT, by resorting to new financial sources. Quite naturally, an application was immediately made to the World Bank Group.

For the expected additional funds to be used as effectively as possible, a co-ordinated structure is required.

This structure must not upset the existing systems in the English or French-speaking West African countries, since most of the funds will, in the future, continue to come from the present sources, and the Governments of the African countries do not expect any modification to a system in which they co-operate closely both financially and technically.

The structure will also have to integrate the existing system without changing the present research procedures, and ensure that the whole of the expansion programme is properly co-ordinated. Lastly, it will have to make it possible to mobilize the funds from new sources.

To solve this problem, an original formula has been proposed for co-operation between the two Institutes at present responsible for the programmes in progress (IRAT and the Ahmadu Bello IAR in Nigeria). Both of these Institutes will retain their own particular features and responsibilities, but they will, in close liaison, implement the expansion programme.

From a practical point of view the African Food Crop Research Programme for the Dry Zone (PRACAZ) would be implemented under the following conditions :

a) a board of directors, consisting of representatives of the countries in which the research centres are set up, together with representatives of IRAT and IAR and, should the occasion arise, representatives of other scientific aid bodies, would form the body responsible for the general execution of the programme and in particular, for approving the programmes.

b) a scientific committee consisting of leading African, European, American or Asian scientists would examine the programme and be responsible for liaison and co-ordination with ICRISAT.

The Programme's scientific committee will apoint some of its members to form, with the scientific committee of ICRISAT, a co-ordinating committee which will determine the links between the work included in the Programme and the work undertaken by ICRISAT, see that operations are not duplicated and provide for permanent exchanges of scientific information between the Programme and ICRISAT.

c) The States involved in the implementation of the Programme (Nigeria, Senegal, Upper Volta, Niger) undertake to make their research centres available for the Programme, ensure that the plants formulated under the Programme may be used freely outside their territories, and undertake to accept the conclusions of the scientific committee and board of directors for this additional programme which is of regional interest.

d) The Programme will be carried out, as at present, by IRAT and IAR who may, in order to form the research teams to be created, call upon research workers of various nationalities. The management secretariats for the Programme and the board of directors will be provided jointly by IRAT and IAR.

A structure of this type seems to provide an appropriate means for solving the problems involved in speeding up food crop research in West Africa and for ensuring close liaison with ICRISAT.

The objectives of the Programme correspond to the urgent activities that must be undertaken to bring about rapidly a substantial improvement in the conditions for producing food crops in the dry zones of West Africa, and thereby improve the standard of living of the populations.

The planned structure would provide for effective work and the independance of the research workers in regard to local constraints, while at the same time respecting the concerns of the different Governments.

Thus implemented, a Programme of this type would form a true regional programme.

The relations planned with ICRISAT make it possible to assert that the funds provided for carrying out the Food Crop Research Programme for the Dry African Zone would be used wisely. It is for this reason that the Technical Advisory Committee is requested to recommend that it be adopted.

A N N E X E S

ANNEX I

RESULTS OF THE RESEARCH UNDERTAKEN IN TROPICAL WEST AFRICA by IRAT

1 - CREATING HIGH YIELDING PLANTS

IRAT has adopted the method of placing the plants used in selection work under greatly improved fertility conditions. The plants chosen for these conditions will have to continue to produce the highest yields under poor fertility conditions.

/a. Cereals/

The varieties already obtained and those expected in the longer or shorter term provide and will provide a wide range of more or less perfected plants suitable for varied growing conditions.

Improvement work has followed two quite separate lines :

1) Improving the "traditional" varieties. This represents the initial phase in which it has been possible to obtain very rapidly new varieties that are easy to extend since they do not require any fundamental changes in cultural techniques. The initial yields have been increased by 25 to 35%.

2) Creating "modern" plants. The plant breeder's work is much longer and the varieties created can only be used with highly improved cultural techniques. But in return, substantial yield increases are obtained.

- Pearl Millet -

Synthetic varieties that exploit heterosis to some extent have been obtained and can be extended or are in the process of being obtained in several countries (yields of 30 quintals on farms).

Dwarf varieties that enable intensive production techniques to be used profitably are being created in Senegal, Upper Volta and Niger. At Bambey, this research has been in progress since 1970, using EDF-EURATOM funds. High-yielding eatly or very early dwarf varieties (70 - 75 days from sowing to heading) with thin stems have already been created, but they are unduly susceptible to Sclerospora graminicola and various grain characteristics are not fully satisfactory. With these varieties, the traditional farming techniques (soil preparation, spacing, fertilizers) must be

completely revised.

The improved traditional varieties show permanent increases of 20 %. Extending these plants does not involve any special problems.

- Sorghum -

Local varieties have been surveyed and selected by IRAT in all the countries where the Institute works on this species.

Varieties have been introduced extensively, with interesting results in several cases.

In addition to the processes for creating hybrids that may be used in the first generation, crosses have been made with a view to extracting lines wich combine the agricultural qualities of proper adaptation and a suitable cycle with the grain characteristics of the local varieties. Work is already well under way on the methods designed to reduce the high straw/grain ratios and lines with a height of 1 to 2 m. are being obtained or tested in all the IRAT Agencies. They will be selected according to their suitability for very dense growing and their response to fertilizers.

Just as for millet, although the improvements produced by selection work on the traditional varieties are not negligible, they have proved to be limited : the increases obtained amount to 15 to 25 %.

The introduced varieties and lines extracted from hybridization provide far better possibilities. Providing strict standards are applied for grain quality, these new varieties may be disseminated extensively and rapidly (with yields of up to 30 to 40 quintals).

- Maize -

Although this is not an important crop in the zone, it is tending to spread in the areas where it may be grown with sorghum. Mention should be made of the maize in Senegal which is grown over about fifty thousand hectares in Casamance, which warrants work by a specialist to create "composites" that are properly suited to the special ecological conditions in this small area which are very different to those in the humid tropics for which IITA undertakes selection work at Ibadan.

/b. Légumes/

- Cowpea (Vigna unguiculata) -

A substantial collection of more than 200 numbers from various parts of the world is kept at Bambey, but in fact more than 800 varieties have already been studied.

These varieties have been tested at Bambey itself and on a number of trial sites outside the Centre. These trials, which have been carried out since 1960, have led to determining an initial range of varieties adapted to the different areas in Senegal with yields ranging from 800 kg/ha to 1 300 kg/ha, but which are not fully satisfactory from other points of view.

The variety improvement work in progress is based on a number of selection criteria which were studied and assessed beforehand. These criteria concern : the variety cycle, growth habits (grouped inflorescence), the presence of anthocyanin on the vegetative organs, flowers and pods, size of the seeds and the number of seeds per plant.

The variety cycle is determined by combining sensitivity to the photoperiod with sensitivity to the thermoperiod, the former being the more important. The desired objective is : a short-cycle variety (75 days from sowing to harvest) which is not influenced by the photoperiod and only slightly by the thermoperiod for the Northern zone. This represents a collection of recessive characters.

The growth habit is either creeping or erect.

The late varieties (short-day) are of the creeping type, and the varieties not influenced by the photoperiod are either creeping or erect. The growth habit itself needs to be specified : a distinction will be made between an erect habit with indefinite growth : twining habit, and an erect habit with defined growth : definite erect habit.

The selection objectives are :

definite erect habit, green pods, cream-coloured seeds with or without cream eye, large seeds.

The hybridization methods have been formulated. Careful use of irrigation in the dry season has considerably speeded up the process of exploiting the crosses and new varieties are obtained after 7 years at the most, which is a definite improvement.

Two lines have been selected, which are moreover very similar to each other since they are descended from the same cross. One (N'Diambour N° 1) is suitable for the Northern zone (Louga), and the other (Daol N° 1) for the central zone. Both are of the creeping type and have cream-coloured seeds. Over 4 years they have produced an average of 15 q/ha of seeds.

- Soya -

This plant is practically unknown in West Africa.

Two important reasons provide arguments for introducing it :

. its "association", in the world, with the crops widely found in the zone (groundnuts, sorghum, cotton),

. the great demand in the developed countries, particularly for soya cake.

The varieties introduced by IRAT (at Bambey in particular) give reason for a certain degree of optimism, but in order to adapt the cycle to the ecological conditions, it is necessary to :

. continue these introductions from a wider range of sources (Japan, China...)

. make selections on a regional basis.

/c. Genetic stock/

Lastly, it should be emphasized that the Bambey ARC keeps collections of types of sorghum, millet, cowpea and groundnuts. Mention has already been made of the 200 numbers of Vigna. Out of the 1 600 numbers of sorghum and millet introduced over the last 20 years, 550 numbers of sorghum and 50 of millet are still kept. The use of cold storage methods means that these plants only need to be grown every 3 years.

The Bambey ARC also operates as a true gene bank for the whole of this West African dry region.

2 - BASIC SEED PRODUCTION - SEED ANALYSIS

To extend the improved or selected seed of the above-mentioned species, it is necessary to set up production and inspection organizations for :

. basic seed

. selected, certified seed, etc.

The Governments of the States involved are engaged in setting up "Seed Services" for the second aspect, at least for the most extensively grown species (millet, sorghum and cowpea for the crops concerned in this paper).

The work on basic seed, which is undertaken by the research bodies, will have to be expanded considerably to cope with the difficult constraints that are already, and will be increasingly, imposed for producing and examining basic seed with more sophisticated formulae (fixed formula hybrids in particular).

This aspect makes it necessary to set up or expand specialized services whose production and inspection methods need to be determined rapidly.

In particular, for the seed quality assessment and analysis methods, research is urgently needed on adapting or formulating suitable techniques for the conditions and plants involved.

At the present time, only one of the States concerned (Senegal) provides this work which is undertaken by IRAT (Bambey). Groundnuts are mainly involved, but basic cereal seed inspection has been started and on some occasions seed has been supplied to Senegal's neighbouring countries.

3 - CROP PROTECTION

The programmes at present being undertaken are centred upon studying (to understand and control) various diseases, insect parasites and weeds, about which a few details are given below.

Of the millet diseases, the most important are mildew (Sclerospora graminicola) and the grain smut (Tolyposporium penicillariae). Variety resistance characters have been found in Senegal and Upper Volta and have been transferred to the new varieties. The Sclerospora inoculation technique has not been perfected however.

A greater number of sorghum diseases are found. Moulds on the grain lower the quality substantially and they should be studied thoroughly. Four smuts are known and seed treatment is effective for two of them. Leaf diseases develop to extremely varying extents according to the variety types and their true effects on output need to be studied.

Of the most dangerous insects, mention should be made of the sorghum shoot fly (Atherigona quadripunctata) which should be studied with a view to obtaining resistant varieties.

Stem borer control is more difficult but is particularly warranted on the short-stemmed varieties.

Detailed studies on the vitality of the populations of cecidomyia and its parasites have been made by IRAT. At the present time, experimental work still has to be carried out to obtain information on control methods.

Striga (a hemiparasitic phanerogam) weighs heavily on the prospects of dry cereals throughout the dry tropical zone. Exhaustive studies, with joint work by the physiologist, agronomist and plant breeder, seem to be warranted to have a greater understanding of the phenomena that control the population and development of this parasitic plant, and formulate control techniques for prevention and eradication.

But the problem of striga must not overshadow the seriousness of the general weed problem. At the present time manual or even mechanical weed control forms a serious bottleneck in efforts to extend the cropped areas and therefore reach farms sizes that are, economically speaking, adequate.

4 - STUDY AND TRANSFORMATION OF THE NATURAL ENVIRONMENT

/a. Soils/

A great number of operations and particularly those carried out by IRAT in Senegal have led to formulating techniques for fundamentally improving the soils in the dry tropical zone, by combining the effects on the physical, chemical and biochemical characteristics. Research has dealt with the following points, for which definite results have been obtained :

- effect of tillage and its frequency; ploughing period and its interaction with the sowing dates; relations between root development and yields;
- fertilizer formulae have been prepared for the main growing regions and for different levels of productivity;
- studies on the dynamics of nitrogen in the soil have been undertaken and have begun to throw new light on some phenomena which had been wrongly interpreted (immobilization of mineral nitrogen in organic form during the rainy season, mineralization process at the rhizosphere level, ...);
- research on crop rotations;
- growing crops under special conditions (sorghum after flooding in the Senegal Valley, sorghum planted out in North Cameroun);
- cultural techniques (sowing rates and methods, mechanical crop care, ...) formulated for most of the regions.

Applying the results of this research in the natural environment has produced substantial yield increases, as is shown in the following table (Senegal results) :

	Site	Yields in kg/ha	
		Without manuring or tillage	With manuring and tillage
Millet	Northern and Central zone	453	978
	Casamance	1.105	2 429
Sorghum	Sine Saloum	893	2 100
	Eastern Zone	1 086	2 365
	Casamance	1 617	2 190
Cowpea	North	653	875

For the soils, mention must be made of the research in the zone carried out at Samaru (Nigeria) within the framework of JP 26, but which deals mainly with maize and only to a lesser extent with millet on which the effect of returning crop residues has been studied (late millet).

/b. Climate factors/

In this zone, the rate and volume of plant production depends upon water Study of these problems has warranted a special programme to examine the economics and rational use of water on the basis of the following subjects :

- measuring PET, AET, RET;
- adjusting formulae and methods for determining the water requirements of the crops;
- critical phases in plant development from the point of view of water nutrition;
- water/soil/plant relation (studies with the neutron moisture meter);
- effects of overall radiation and temperature.

5 - INTENSIFICATION OF THE CROPPING SYSTEMS

The main features of traditional agriculture are :

- the use of hardy plants
- essentially manual cultivation
- adequate land to maintain a low but constant fertility level
- small sized farms with low outputs
- a self-sufficient economic system.

For a long time, this agricultural system formed part of the balance in the environment.

Now that fallows have been shortened or even completely eliminated due to the population increase, the natural fertility level is no longer maintained.

Introducing cash crops and setting up a market economy has also upset the natural balance. Because of the low output of traditional crops and the new availability of money, the populations tend to consume new foodstuffs that are not produced on the farms (rice, wheat, etc.).

The traditional peasant farm has become outdated. Modernized production systems must be formulated that utilize all the knowledge acquired in the various fields of research and are properly adapted to the present human and economic situation.

The work in Senegal on this subject is based upon research results on soil fertility and potentialities and the crop suitability of the different regions. This work involves all the scientific branches and includes, in particular, studies on the following aspects :

- New cultural techniques connected with problems concerning fertility, soil physics (ploughing) and the particular requirements of new plants (dwarf cereal varieties for example);
- Mechanical equipment, especially for use with draught cattle, that is suitable for implementing these techniques;
- Crop rotations : crop sequence and fertilizing;
- Labour requirements of the farm according to the climate constraints, the work and mechanical equipment that can be used.

By integrating the results of this work, farm models can be designed for different ecological situations.

Models of this type have been tested on several sites in Senegal. By using them it is possible to adapt the technical

innovations more satisfactorily and study the constraints and interactions they produce when combined and also assess the economic effects.

Beyond this study phase in the station, IRAT has felt the need to tackle the agricultural, economic and human problems involved in introducing new techniques into the rural environment itself.

This forms the objective of the Experimental Development Units set up in South and East Sine Saloum.

6 - POST-HARVEST TECHNOLOGY

The trend of consumers to abandon some traditional foodstuffs that take far too long to prepare is a relatively new fact but one that is being found more and more frequently, especially for pearl millet.

This cereal, which is favoured by the populations, will only remain a staple element in the consumer can be given new, simple, rapid techniques which make it as easy to prepare as rice for example.

In particular, a method must be found for producing a stabilized flour after hulling and milling, even in the village, if the research and development efforts being undertaken to modernize the growing of this nutritious cereal are to serve any purpose.

A substantial contribution to solving some of these problems has been made by the studies at Bombey on millet threshing at the village level and by perfecting various types of metal and concrete silos. But the scope for work is vast and these questions should be dealt with in conjonction with specialists in stored produce protection.

7 - STORED PRODUCE PROTECTION

Everyone is aware of how serious a problem stored produce protection involves in the tropical countries. In West Africa, it is estimated that, after harvesting, a quarter of the food output is lost in the different stages between production and consumption. For millet, sorghum and the food legumes the amount lost is even greater, particularly for cowpea which is rapidly destroyed in a few months, mainly bu bruchids. There is of course no lack of modern storage techniques, but we must adapt them to each case and for all levels from household to industrial storage, and make them acceptable to the user according to his needs, customs and economic possibilities.

The studies so far undertaken have led to formulating simple techniques that may be used by the farmer and are relatively inexpensive. In particular interesting results are obtained by storing cowpea in plastic bags and protecting the seeds stored in this way carbon tetrachloride - but with new equipment and new pesticides appearing on the market it is necessary to revise the results obtained and seek new techniques that are more reliable or simply less expensive.

Extraits du Rapport

MINGS - DOGGET - SAUGER

A basic premise of this proposal is that the Institute should be set up and should function in such a manner as to strengthen and support national programs with the crops and topics concerned, both in the host country and in other nations, rather than compete with or replace national programs. Further, it would expect to develop close linkages with such national and regional programs in all parts of the world having similar ranges of ecological conditions and in which these crops appear to have high potential value.

The team wishes to emphasize these principles strongly and to suggest that the trustees and staff of the Institute keep them prominently in view as the Institute and its programs are established.

In recommending the establishmentof a single major institute, the team recognizes that this can meet the needs effectively only if it is closely linked with, serves, and maintains close working relationships and communication with a series of regional and national programs throughout the relevant areas of the world. The International Rice Research Institute (IRRI) provides an excellent model of how this can work. Without going into detail, suffice to say that very close working relationships have been established with national programs in the Philippines, Korea, Japan, Vietnam, Indonesia, Republic of China, Malaysia, Thailand, East and West Pakistan, India, and Ceylon. Some of these national programs have been linked formally to IRRI by contracts between IRRI and foundations or government agencies providing direct support to some phases of the respective country programs. In other cases, the relationships have been less formal. In all cases, however, these countries have had free access to all the genetic materials in the Institute which they wished for and could use. They have sent trainers to IRRI and their scientists have participated in IRRI workshops and seminars. There have been frequent and numerous visits of IRRI staff members to these countries for consultation and of national program staff members, administrators, and program leaders to IRRI.

Outside Asia, other international research institutes (CIAT and IITA) have added rice specialists with experience at IRRI to their core staffs to assist in developing regional rice improvement programs in their respective regions (Latin America and Africa), being able to draw upon IRRI's resources in materials, staff, and training facilities for support.

Recently, the West African Rice Development Association has been organized, with FAO and UNDP support, to facilitate regional cooperation in rice production research and improvement in West Africa. Again the materials, staff resources, and training facilities of IRRI can be drawn on for support to this regional program.

Links with other national and/or regional programs are being established. A similar outreach program is being developed by CIMMYT for wheat and maize growing countries. It is visualized that ICRISAT will take advantage of this experience in developing close linkages to regional and national programs in the various parts of the world it is designed to serve. Success is due in large part to flexibility of organization, coordination of effort, and the conduct of the applied stages of the research in the areas where the crop is actually to be grown.

It is suggested that the system which has come into being in association with IRRI may be regarded as a reasonable model for ICRISAT. It is suggested that the main center should concentrate on the basic problems and assure that the full range of genetic materials of these crops is made available to all stations desiring them. Unless such a chain of stations is associated with the Institute, its effectiveness will be very restricted. It is therefore recommended that, parallel with the establishment of the Institute, support be given for strengthening associated research activities on selected government stations or university sites throughout the belt of the dryland tropics. Such a strengthening of local effort appears vital to the full success of ICRISAT. In order for this effort to be most effective and in the interest of assuring the closest possible coordination, the Institute could well be the medium through which additional resources for strengthening national and regional programs could be channeled. This could take the form of grants or contracts with the Institute to provide for support to specified regional or national programs. While providing a certain amount of money to the basic support of the Institute, at least some of the assistance agencies may also wish to initiate and to be responsible for such specific projects in individual countries.

Africa has several regional programs for work on sorghum and millets. In West Africa, Bambey serves the Savannah zone for short term sorghum and millets, while Samaru under project 26 with STRC/OAU serves the whole region. Its logical ecological region, however, is the guinea sorghum belt, where the long term varieties of sorghum and millet are grown.

.../

West Africa

Outside of India, a significant portion of the sorghums and millets (Pennisetum millet) to be found in the ecological zone of concern to ICRISAT, is grown in West Africa.

Important work is actually being carried out in that part of the world, in Senegal, and Niger, by IRAT on short-term millets and sorghums (80 to 100 days), and in Nigeria through the joint project n°26 and in Upper Volta again by IRAT for the long-term millets and sorghums (120 to 150 days). The first group is principally located in ecological zone V4 (2 to 4 1/2 months of rainy season) and the second group in zone V 3 (4 1/2 to 7 months of rainy season) as described in Gray's report.

The mechanism outlined earlier for East Africa could very well be adopted in this area although several factors peculiar to this region would have to be taken into account :

- firstly, a great number of countries are involved, some being anglophone and others being francophone ;
- secondly, there already exist networks of research for the same crops extending over all of these countries. One of these is provided by IRAT in francophone countries within the framework of the needs as they are defined by the different governments and through joint financing by the countries concerned, by France and by other agencies. The other is joint project n° 26 of the OAU which is financed by USAID and which is concerned with cereals within the countries of that part of Africa ;
- thirdly, certain programs which would normally be under the responsability of the new Institute because of their general scope are already being intensely pursued in this zone and care should be taken to avoid their duplication or suspension. This is the case for basic studies on the physiology and genetics of cereals or on soil sciences, as well as for studies of a more practical nature such as agricultural engineering and production systems.

It should then be agreed :

- on the one hand that the programs of the Institute take into account research now being done in these countries in order to avoid duplications, with the understanding that there would be a free exchange of research results ;

.../

- on the other hand that the outreach programs of the Institute be channeled through the network of existing research programs, one for short-term cereals, the other for long-term cereals. This constitutes an advantage for simplifying linkages rather than having to deal with each country separately since the dialogue would be engaged with two regional organizations that represented by IRAT and the other by joint project n° 26.

The Bambey center in Senegal, thus associated to the International Institute, with its secondary stations, would be the relay station for short-term millets and sorghums. Senegal in this respect has the advantage of providing across a North to South distance of 500 km, at less than 300 km from Bambey, the entire range of rainfall from 300 to 1,500 mm. This allows for the selection of the best combinations of varieties, of cropping patterns and of production systems to be recommended for the zone. The possibility of envisaging year round irrigation at Richard-Toll should be considered as a favorable asset in expediting the research work. Dissemination to other countries could be rapidly achieved due to the existing network. Samaru would serve as a relay to Bambey for the anglophone countries concerned with short-term cereals.

The Samaru center in Nigeria would be similarly associated to the International Institute for long-term millets and sorghums and the dissemination would be provided through the existing joint project n° 26. Bobo-Dioulasso in Upper Volta would serve as a relay to Samaru for francophone countries for these long-term cereals.

None of the grain-legume crops chosen for ICRISAT are now extensively grown in West Africa although the same allocation between Samaru and Bambey, based on the ecological requirements, could apply as well for those legumes crops (ex. cowpea) which are important to the region.

The same principle applies to the study of farming systems which will have to integrate these different crops in addition to cotton, in varying proportions according to the ecologies, the soils and the social customs.

WORKS ON SORGHUM, MILLET AND MAIZE

AT IAR (SAMARU)

SORGHUM

Improved local varieties have been selected and recommended for the major sorghum growing zones (see list). Work on local varieties stopped in 1970.

Higher yields are now being sought through dwarf varieties and hybrids which will allow more intensive cultivation and higher fertilizer rates. These varieties/hybrids however need to be quite specifically adapted to the different ecological zones because of the requirement that heading should be at the end of the rainy period.

The alternative approach of using non-sensitive varieties, and varying the date of planting so as to obtain maturity at the correct period, is being investigated.

Dwarf sorghums are being bred both by crossing and selection, and in composites, using genetic male sterility.

In 1971 Dwarf varieties have given yields of up to 4,000 kg/ha and an experimental hybrid gave 5,000 kg/ha.

MILLET

Breeding work is performed on both the main types of millet, "gero" (early millet) and "maiwa" (late, photosensitive millet). Gero types have rather a wide adaptation while maiwa varieties are of limited adaptability.

Selected local varieties have been produced both of gero and maiwa, but gains have been less than 15 %, though yields of 2,500 - 3,00 kg/ha can be obtained with these types.

Dwarf synthetics and composites have been formed though difficulty is being experienced with downy mildew, grain smut, and sugary disease. Dwarf Experimental A-B lines of both the gero and maiwa type have been produced, and hybrid testing will commence in 1972.

MAIZE

The future possibility of high maize yields in the Guinea and Sudan Savannas must be considered in relation to the millet/sorghum research. Maize yields of 6-7,000 kg/ha and more have regularly been obtained at high rates of fertilizer on research and Government farms, and thus farmers willing to use advanced farming practices may be more attracted to maize.

INSTITUTE FOR AGRICULTURAL RESEARCH
Sorghum Seed Multiplication
Northern States of Nigeria

Local varieties

Improved local varieties of Sorghum are recommended according to the following list (effective January, 1971)

Location	Selection	Zone	% Improvement of selection
Kafinsoli, Gusau, Birmin Kudu, Potiskum, Fika, Kano	YG 5760-3-10	Sudan Savanna	18 %
Maiduguri	G59	Eastern Sudan Savanna	26 %
Gwoza	G26-3-1		111 %
Zaria, Darazo, T. Fana, Daudawa	SFF60	Northern Guinea Savanna	6 %
Osara	SFF60	Derived Savanna	34 %
Zuru, Samaru, Mubi, Hong	FFBL3-1-6	Northern Guinea Savanna	20 %
Kaiama, Mokwa, Kwali, Lafia, Yandev, Lowlands, Jalingo, Ganye	MFC7-4-2	Southern Guinea and Derived Savanna	24 %
Lowlands, Osara	FD1	Southern Guinea and Derived Savanna	46 %
Osara	ML4	Southern Guinea and Derived Savanna	38 %

Dwarf Sorghum Varieties are recommended in the Northern Guinea zone at the following places.

Location	Variety	Average yield in trial (Minimum 3Yrs
Zaria area	SK 5912	3,159
Zaria area	CK-FF 2123	1,854
Daudawa	CK-FF 2123	2,042
Zonkwa	SK 5912	920
Bauchi	SK 5912	2,237
Hong	SK 5912	2,219
Hong	gSK-WX 2141	2,419

A suggested 3 stage system of multiplication of sorghum varieties is outlined below which will realise about 70 tons of seed per year.

Stage 0

1/4 acre (including discards) Planted from Foundation seed supplied annually from IAR yields 50 lb pure seed excluding produce of discard edge area.

Stage I

2½ acre (including discards) Planted from Stage 0 seed. Yields 2,250 lb (at 1,000 lb/acre) excluding discard. Multiplication rate approx. x 90.

Stage II

200 acre Yields 160,000 lb (at 800 lb/acre) Multiplication rate approx x 80. Sufficient to sell to farmers to plant 16,000 acres.

Note : Planting annually at 3 years all stages will be planted in the same year. If guaranteed storage exists a larger Stage 0 could be planted biennually to supply 2 years of Stage I.

Cost

Approximate costs of cultivation on multiplication scheme (does not include cost of land, supervision, storage or transport).

Sorghum, per acre

Seeding, cultivation, mechanical and hand	£ 10
Fertilizer	3
Harvesting and threshing	3
Bags and insecticide	2
Total	£ 18

One unit of multiplication (Stages 0 and I) cost 18 x 2 3/4 acre = £ 50 and produce 2,250 lb seed, which will plant 225 acre. At £ 25 per ton 2,250 lb = £ 25. Therefore to pay for the cost of multiplication seed for Stage II should be sold at 5.4 pence per lb or 4/6d per acre (AO lb).

Note Stage II is not costed here since it largely depends on price paid to contract farmer. It is suggested that price to be paid to such a farmer is fixed before sowing, and that the farmer is guaranteed a basic return per acre provided he has complied with the instructions for cultivation.

Cultivation

As per Samaru Technical notes Vol. I AI.1, but Stages 0 and I should receive at least double the normal amount of fertilizer.

Essential points

Seed rate of 10 lb/acre assumed (hand planting) (6 lb/acre if machine planted). Stages 0, and I to be carefully grown on Farm Centres with adequate isolation distances (400yards) from other sorghum, with perimeter discard to plots.

Stage II presumably will be on selected farmers'farms (but see modified system below). Some contamination is bound to occur at this stage and harvested seed should not be used for further multiplication. The main part of the cost, as with all schemes, will be at this stage, and will greatly depend on what price it is necessary to pay to the contract farmer to back the seed.

Ease of roguing. All tall varieties mentioned above closely resemble the respective unimproved types and are hard to rogue. Therefore instructions for discards and isolation distances should be observed.

Dwarf varieties, while liable to be contaminated to the same extent as the tall varieties, are easy to rogue, as the off-types are usually tall and can be totally eliminated before flowering.

Modified system of multiplication

It may be desirable to grow a limited amount of Stage II on State farms. The disposal of Stage I crop would be modified :

Stage I 2 ½ acres Yields 2,250 lb cleaned seed.

divide

1,950 lb sell to farmers (plants 195 acres)	300 lb to plant 30 acres of Stage II on State farms. Yields 30,000 lb for sale to farmers

Total seed production from modified system is 31,950 lb (say 32,000), enough to plant 3,200 acres.

Costs (modified system)

Stages 0 and I	£ 45
Stage II (30 acres)	£540
Handling (1d per lb) and bagging (1/-per bag) costs (i.e.turning out 3,200 bags of 10 lb each)	£293
	£878

Return

3,200 lb seed at 6d lb at planting time	£800
3,250 bags at cost (1/- per bag	£160
	£960

(i.é one 10 lb bag costs a total of 6/-to buy)

Seed sold at 6d per lb at planting time would result in a gain of £82 on seed to plant 3,200 acres. Higher yields on the multiplication areas would enable seed to be sold at a cheaper rate.

D.J. Andrews.

AGRONOMICAL RESEARCH STAFF IN NORTH NIGERIA

		Breeder	Pathologist	Entomologist	Agronomist	Soil Scientist	Rural Economy	Physiology	Farm Manager	
Sorghum - Millet	ANDREWS	/								
	AWONLYE (Kano)	/								
	HANCOCK								30	
	DOEMING			50						
	* YORK			/						
	* KING		80							
	* STOCKINGER					40				
	* TATUM	20								
	OGBORN				60					
	KASSAM							70		
	BAKER				50					
	NORMAN						20			
	BONTJER						20			
	PALMER				40					
	YAYOCK (Kano)				10					
	MANZO		80							
	Ext. Research Liason				20		20		20	
	HEATHCOTE					50				
Cowpea	LELEJE (Kano)	/								
	AGRONOMISTS (Kano)				30					
	CASWELL			20						
Soya	VAN RHEENAN (Mokwa)	50								
	AGRONOMISTS(Mokwa)				20					
	FARM MANAGER								20	
		3.7	1.6	1.7	2.3	0.9	0.6	0.7	0.7	12.2

The figures point out the percentage of time spent by the scientist on the concerned crop.

* - J.P. 26

MEAN COST OF RESEARCH STAFF

(SAMARU)

Cost per man/annum - £ N 12,500

1 £ N = 3 U.S. $

Recurrent

Salary	2,600* (2,000 - 3,200)
Assistants emoluments	2,800
Daily paid staff	1,700
Supplies	1,500
Travel	1,000
Administration, (proportion)	1,600
Conference cost	600
Miscellaneous	700
	14,500

Capital

Housing (1)	8,000
Laboratory	4,000

(1) Housing rent (instead of building) = £ 1,200 p. a.

* Does not include any expatriate allowances (British : 700 - Dutch : 900 - AID > 900).